Comment on "Dispersion-Independent High-Visibility Quantum Interference ..."

Yoon-Ho Kim, Sergei P. Kulik,* Morton H. Rubin, and Yanhua Shih
Department of Physics, University of Maryland, Baltimore County, Baltimore, Maryland 21250
(Revised 05 September, 2000)

Recently Atatüre *et al.* claimed to "recover" high-visibility quantum interference in femtosecond pulse pumped type-II Spontaneous Parametric Down-Conversion (SPDC) using neither spectral post-selection nor a thin nonlinear crystal [1]. We show in this Comment that the interpretation of experimental data as well as the theory presented in Ref.[1] are incorrect and discuss why such a scheme cannot be used to "recover" high-visibility quantum interference.

Let us first discuss the theory presented in Ref.[1]. Equation (8) is incorrect and, consequently, so is Eq.(10). According to Eq.(10), the coincidence counting rate should have a $\sin^2(\theta_1+\theta_2)$ modulation with 100% visibility for *arbitrary angles of* θ_1 *and* θ_2 when $\tau=0$. As we shall see in our experiment, this is not so. This is because for arbitrary θ_1 and θ_2, there should be two more terms,i.e., $\cos(\pi/4-\theta_1)\sin(\pi/4-\theta_2)[\mathcal{A}(t_1,t_2+\tau)-\mathcal{A}(t_2+\tau,t_1)]-\sin(\pi/4-\theta_1)\cos(\pi/4-\theta_2)[\mathcal{A}(t_1+\tau,t_2)-\mathcal{A}(t_2,t_1+\tau)]$, which cannot be ignored in Eq.(8). These two terms have no overlap if $\tau=0$. This will reduce the visibility of the polarization correlation at arbitrary θ_1 and θ_2 except at the H and V settings of the analyzers.

To demonstrate Eq.(10) in Ref.[1] is incorrect, we have performed an experiment which is identical to Fig.1 in Ref.[1] in which the polarization correlation is measured. When $\theta_1=90°(H)$ or $0°(V)$ high-visibility modulation is observed as θ_2 is varied, see Fig.1(a). This is what Atatüre *et al.* observed in Ref.[1]. However, at $\theta_1=45°$, the visibility is immediately reduced to 16% [Fig.1(b)].

This means that the "X-Y delay" at $\tau=0$ does not "recover" the quantum interference as the authors expected. In fact, one can observe the same interference pattern when the "X-Y delay" is absent. To show this, we removed the "X-Y delay" from the setup, set $\theta_1=90°$, and varied θ_2. The "visibility" is ≈100%, see Fig.1(c). Setting $\theta_1=45°(H)$ and varying θ_2 again, as evident from Fig.1(d), the visibility is as low as 16%. This demonstrates that the "X-Y delay" has no net physical effect when $\tau=0$. This also shows that what is observed in Ref.[1] is not quantum interference. It simply shows that the signal is V-polarized and the idler is H-polarized.

These data clear show that $|V\rangle|H\rangle$ has not been transformed to $|X\rangle|X\rangle-|Y\rangle|Y\rangle$ as the authors claim [Eq.(10)]. In fact, such a "cascaded transformation of the two-photon state" cannot occur unless proper longitudinal compensation is made first [2]. Therefore, it is obvious that this kind of scheme cannot be used to "recover" quantum interference. We also note that Fig.3 in Ref.[1] might lead to confusion since readers might mistakenly consider it to show space-time interference. In fact, only polarization correlation measurement is observed in Ref.[1] at a fixed angle $\theta_1=0°$.

It is true that Atatüre *et al.* made some kind of polarization state transformation of biphotons. Certainly these transformations are related to τ and the pump pulse duration (For a general description of polarization transformation of biphotons, see Ref.[3]). It, however, has nothing to do with the "recovery" of quantum interference as they claim.

In conclusion, we have experimentally and theoretically shown that Atatüre *et al.*'s claim to be in error. Neither the experimental data nor the correct theory support their claim. Finally, we would like to mention that we have recently developed a new method of generating entangled photon pairs pumped by femtosecond pulses which shows true high-visibility quantum interference [4].

[1] M. Atatüre, A.V. Sergienko, B.E.A. Saleh, and M.C. Teich, Phys. Rev. Lett. **84**, 618 (2000).
[2] M.H. Rubin, D.N. Klyshko, Y.H. Shih, and A.V. Sergienko, Phys. Rev. A **50**, 5122 (1994).
[3] A.V. Burlakov and D.N. Klyshko, JETP Lett. **69**, 839 (1999).
[4] Y.-H. Kim, S.P. Kulik, and Y.H. Shih, Phys. Rev. A. **62**, 011802(R) (2000); \protect\vrule width0pt\protect\href{http://arXiv.org/abs

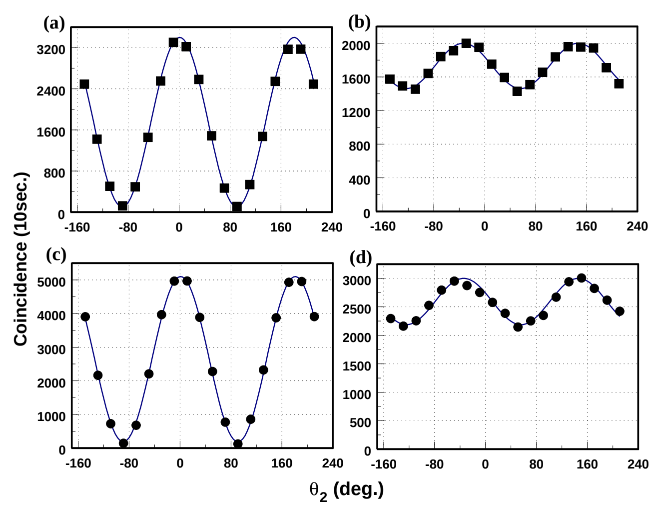

FIG. 1. Experimental data. With "X-Y delay"($\tau=0$): (a) $\theta_1=90°$, (b) $\theta_1=45°$. Without "X-Y delay": (c) $\theta_1=90°$, (d) $\theta_1=45°$.

*Permanent address: Department of Physics, Moscow State University, Moscow, 119899, Russia.